

Novel modified Peyton's approach for knowledge retention on newborn life support training in medical students

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Abstract

Aim: We sought to improve retention of neonatal resuscitation skills by modifying step 3 through additional functional verbalisation in Peyton's four-step approach (P4S).

Methods: Newborn life support (NLS) training was performed in a simulation-based setting. In contrast to the traditional approach, students taught with the modified approach were requested to explain every step of their performance in Peyton's step 3. A total of 123 students were allocated into both experimental groups. Students were then assessed by megacode on day four (initial assessment) and 6 months (follow-up assessment).

Results: Both groups showed similar scorings in the initial, follow-up assessment and in mean change. On initial megacode, time to start with initial inflation and post-resuscitation care was significantly faster in the control group. All showed a significant loss of performance irrespective of modification in step 3 in the follow-up assessment. Only time until start with post-resuscitation care shows a significant group difference in mean change between initial and follow-up with increasing time in the control and decreasing time span in intervention group.

Conclusion: Both methods showed equal levels of knowledge acquisition and long-term decline in NLS performances. Verbalisation in step 3 influenced speed of applied NLS performance.

KEYWORDS

clinical skills, instructional approach, newborn life support, Peyton, undergraduate medical education

1 | INTRODUCTION

Neonatal life support (NLS) in the delivery room requires the acquisition of cognitive and technical skills. As time after birth is one of the

most critical periods in life, disorders during this process of postnatal adaptation may have a long-lasting impact on health.¹ Up to 10% of newborns may require basic and short support by means of bag-mask ventilation to establish a regular respiration. With an raising number of primary caesarean section over the last two decades, the

Abbreviations: ACLS, advanced cardiac life support; BLS, basic life support; bpm, bits per minute; CPR, cardiopulmonary resuscitation; ERC, European resuscitation council; NLS, newborn life support; P4S, Peyton's four-step approach; PBLs, paediatric basic life support.

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amount of newborns requiring bag-mask ventilation has increased, too.² However, almost 1% of term newborns need resuscitation including endotracheal intubation or chest compressions due to cardiopulmonary insufficiencies.³ Inadequate postnatal assessment and resuscitation of the critically ill newborn can result in severe birth complications. Fast and structured acting of medical staff during initial care in the delivery room improves the neonatal outcome and may prevent serious asphyxia which is associated with increased neonatal morbidity and mortality.⁴

Newborn life support is a critical procedure and requires trained and refined psychomotor and procedural skills from health care professionals.⁵ Simulation-based training is effective to improve both theoretical knowledge and practical skills for diverse medical emergencies such as NLS.⁶ There is a focus on simulation in the 2015 revised European resuscitation guidelines (ERC), making it a central part of training during medical school and residency.^{7,8} Simulation-based learning strategies have a favourable impact on self-efficacy and motivation for learning that effects acquisition of practical clinical skills and long-term retention.⁹ These can be integrated into teaching methods to promote active learning and professional competence.¹⁰ The simulation itself also allows repetitive practice of algorithms and the possibility of utilising different teaching methods.¹¹⁻¹³ There is a need for simple teaching methods every teacher can adopt, which are accepted by the students and provide a sustainable outcome. In life support training sessions, the skill acquisition is more frequently taught by the Peyton's four-step approach (P4S).¹⁴

The teaching method was originally developed by Peyton more than 20 years ago and is based on four steps of instruction¹⁵:

- Demonstration step 1: Demonstration of the skill at normal speed without any explanation.
- Deconstruction step 2: Repetition of the steps of the skill with full explanation. The trainer answers questions of the trainees.
- Comprehension step 3: Trainer performs the skill guided by the explanations of the learner. The trainer repeats this step until correct demonstration and achievement of full understanding. The description and execution do not occur simultaneously.
- Performance step 4: Trainee carries out the skill under the supervision of the trainer. Finally, the trainee receives short feedback.

Peyton's four-step approach combines various aspects of learning theory. Steps 1 and 2, demonstration and deconstruction, are based on the theory of model learning. Step 3, comprehension, is of utmost importance, signifying the major deviation from standard instruction. In order to be able to advise the trainer what to do, the trainee must first reflect upon what he or she learned in steps 1 and 2. The reflection is a crucial step in processing new information; it leads to the definition of a problem, the development of a solution and finally the testing of the solution by action. Trainee's instructing the trainer additionally incorporates aspects of the 'learning-by-teaching' approach, which assumes that learning contents are retained to a higher degree when they are actively taught to another person. In addition, the teacher may give hints or corrections if a

Key notes

- Newborn life support (NLS) is an important medical skill to learn; therefore, we compared long-term skill retention after NLS training between traditional and modified Peyton's four-step approach.
- Our data show equal performance and loss of knowledge for both approaches, though modification in step 3 may improve the speed of NLS.
- Additional investigations are necessary to answer the question how knowledge retention after skill training can be more optimised.

step is forgotten or explained incorrectly by the trainee, which will lead to better understanding. Step 4, performance, comprises an independent performance of the learned skill. Steps 1 and 2 are based on a social-cognitive approach to learning theory, whereas step 4, the actual implementation and training of the procedure up to its successful application, is associated with the behaviourist learning theory.

For standard learning situations, P4S is an accepted and feasible compromise. Prior studies assessed the effects of the single steps in P4S on the learning success. They demonstrated that the third step was the most crucial part since processing of the information from first and second steps must be actively manipulated during the third step to facilitate transfer into the long-term memory.¹⁶⁻¹⁸ Nevertheless, other studies demonstrated that loss of knowledge and decline in practical performance is an eminent problem to be solved when teaching NLS.¹⁹ Although step three proved to be the most important part within the P4S, optimal strategy of verbalisation and instruction in this critical step remains uncertain, particularly in the field of NLS training. In the standard approach of step three, the instructor asks the trainee to describe the order of steps and to perform individual skills. The comprehension rather than mere performance of the task is essential for a better learning and an enhanced retention.²⁰

This is the first study on NLS training evaluating an initial and long-term learning effect by modifying step 3 in Peyton's four-step approach through narration of additional functional contents during step 3 in comparison with the unmodified, traditional P4S approach. We hypothesised that additional functional explanation during step 3 would improve initial and long-term knowledge as well as practical skill retention.

2 | MATERIAL AND METHODS

2.1 | Study design and participants

This was a single-blinded, prospective randomised controlled trial. The present study prospectively investigated the learning outcome

of two different instructional approaches in the context of acquiring procedural technical skills and its long-term retention. To compare the performance, we conducted an initial megacode assessment 4 days after the training and a long-term follow-up assessment 6 months later (Figure 1). All participants were 4th to 5th year medical students participating in a curricular 1-week paediatric internship at the Medical Center of Saarland University, Homburg, Germany. The trainer (TE) was a neonatologist and PALS provider with extended experience in teaching skills following the P4S approach.

2.2 | Data acquisition

The study was conducted over a period of 1 year, beginning with weekly 1-day training session over 12 weeks with one group per week, respectively. All data were collected in the clinical skills laboratory at the Medical Center of Saarland University, Homburg, Germany. The study was approved by the local institutional ethics committee. Written informed consent was obtained, and all students were assured that participation is voluntary and would not influence their grades for the internship. The participants were not informed about the aim and about the different instruction methods of the study. Prior to the training, pre-course knowledge of the students on NLS was evaluated with a 28-question multiple-choice test. The questions of the written test based on the items contained

in the 2015 ERC Guidelines for resuscitation and support of transition of babies at birth.⁷ Each correctly answered question received a score of 1, with total scores ranging from 0 to 28. Before the training, the participants were also asked to self-rate their competence of the newborn resuscitation skills on a 6-point Likert scale (1 = totally competent to 6 = no competent).

2.3 | Megacode

To measure the success of the training, performance was assessed on the same megacode scenario in which each participant was asked to care a depressed newborn in the delivery room as a single rescuer according to the revised ERC guidelines.

The following standardised text was used: 'You are a resident at a neonatal care unit and attending a primary caesarean section of a term newborn in the delivery room. You have 1 minute before delivery of the baby to prepare the equipment'. The trainee was expected to check all equipment regarding the temperature control, opening the airway and aerating the lungs. After the initial preparation part, the megacode was continued with the following text: 'Following delivery, the newborn is cyanotic and doesn't cry. The mannequin under the radiant warmer unit represents the newborn. Please care of the newborn!'. The trainee was asked to make short comments simultaneously to their actions. The scheme of the mock scenario was as follows: At the beginning, the

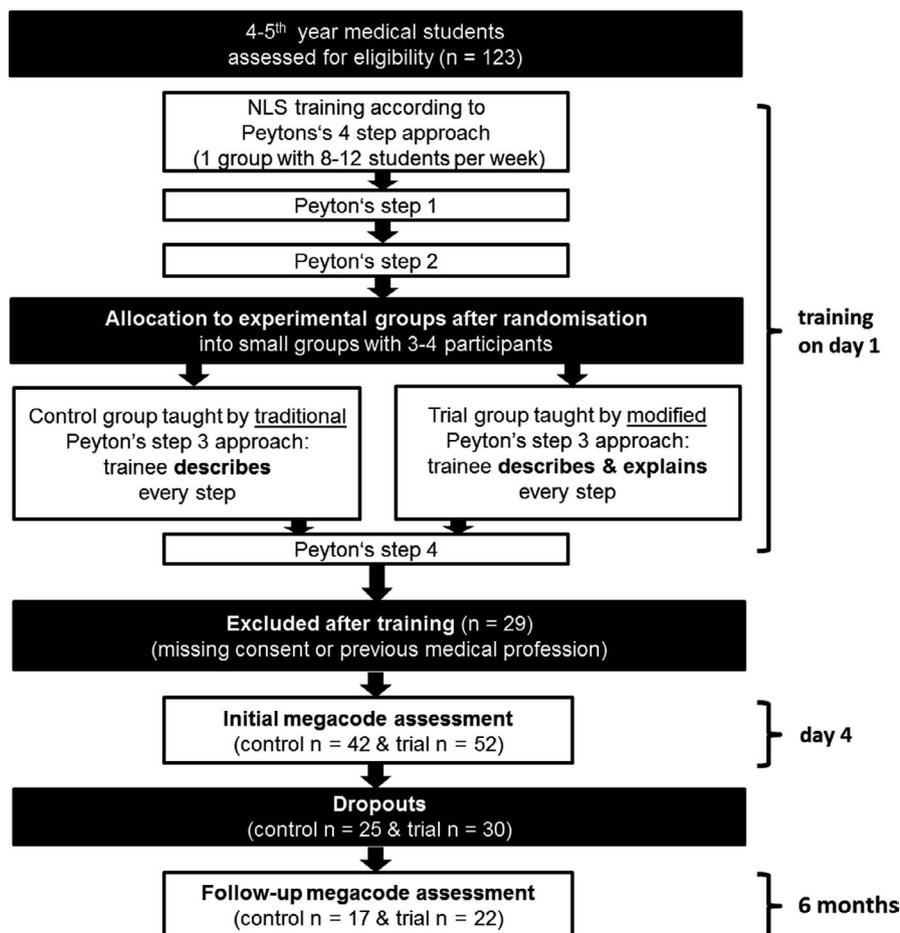


FIGURE 1 Flow chart of the study design

	Steps	Actions/Decisions	Points* (0-1-2)	Time
1	equipment-check	Checks bag, mask and oxygen supply		
		Attends to temperature management		
2	temperature control	Dries, removes wet towels and stimulates		Start with NLS:
3	initial assessment	Checks/requests description of breathing, HR and tone		
4	airway & initial inflation	Indicates need for assisted ventilation (infant is apnoeic or HR <100/min)		
		Positions (in sniffing position and on shoulder roll), suctions mouth, then nose		
		Applies 5 positive pressure inflations correctly (maintains the inflation pressure for 2–3 s)		Start with initial ventilation:
5	re-assess	Checks for improvement in heart rate and for chest rising		
6	ventilation	Identifies need for ongoing assisted ventilation (HF 60-100/min or inconsistently breathing)		
		Continues assisted ventilation (appropriate rate 30-40/min and 1s inspiratory time)		
7	re-assess	Identifies that baby adequately resuscitated (evaluation shows that HR >100, breathing, crying and pink; student should stop PPV)		
8	post-resuscitation care	Warms and maintains normal temperature, starts SPO2-Monitoring on right hand		Start with post-resuscitation care:
	overall performance	Performed all 5 bold/shaded critical items		
		Actions were performed without critical delay		
		Actions were performed continuously from the head of the radiant warmer unit		
Total points			30	

*Item rating: 0 = not done, 1 = partially done and 2 = done correctly

FIGURE 2 Checklist of the megacode

TABLE 1 Instructions and corresponding explanations of single NLS steps

Steps	Instructions (control + trial)	Explanations (trial)
Temperature control & stimulation	<ul style="list-style-type: none"> Remove wet towels Dry and cover apart the face the head and body of the mannequin with provided warm towels Perform a brief period of tactile stimulation 	<ul style="list-style-type: none"> Newborns get cold very easily, which leads to cold stress and impaired adaptation Preheating the radiant warmer and drying keeps the newborn warm Stimulation helps to induce effective heart rate and breathing
Initial assessment	<ul style="list-style-type: none"> Newborn with inadequate breathing, low or undetectable heart rate and reduced tone needs further support Judge the heart rate by listening to the apex beat with a stethoscope Check the breathing by looking for chest movements and by bilateral auscultation Check the muscle tone 	<ul style="list-style-type: none"> Accurately assessment indicates, whether the baby is responding to previous efforts and whether further support is needed Heart rate is the most sensitive indicator A very floppy baby is likely to need resuscitation
Airway & initial inflation	<ul style="list-style-type: none"> Position the mannequin's head in neutral position on a shoulder roll Suction the oropharynx Avoid aggressive and to deep suction Apply five positive pressure inflations with 30 cm H₂O and maintain inflation for 2-3 s 	<ul style="list-style-type: none"> Airway might be obstructed and must be open before the baby can inflated effectively Newborns have a relatively prominent occiput, which tends to flex the neck if the baby is placed on a flat surface Fluid, mucus, blood clots, vernix or meconium in the oropharynx might obstruct the airway Aggressive pharyngeal suction can cause laryngeal spasm and vagal bradycardia Lungs are filled with fluid and expansion of the lungs require initial inflation pressures of 30 cm of H₂O for 2-3 s
Re-assess	<ul style="list-style-type: none"> Observe whether chest passively moves with each inflation Evaluate heart rate and breathing If chest and heart rate does not rise, then reposition mask and newborn's head, consider oropharyngeal re-suction Repeat initial five inflations and ensure that lungs have been aerated successfully 	<ul style="list-style-type: none"> Lung aeration has been achieved Successful aeration of the lungs leads to prompt rise of the pulse Correct for mask leakage and airway obstruction Lungs must be inflated before effective ventilation and/or chest compression can be delivered
Ventilation	<ul style="list-style-type: none"> If heart rate increases between 60-100 bpm, then continue ventilation at rate of 30/min each for 1 s Continue ventilation until the newborn establishes regular breathing and heart rate maintains above 100 bpm 	<ul style="list-style-type: none"> Newborn's breathing is insufficient to provide heart with sufficient oxygen and needs further respiratory support
Chest compressions	<ul style="list-style-type: none"> If heart rate remains below 60 bpm or is undetectable after confirmed initial lung inflations, start chest compressions Place index-middle fingers of the left hand over the lower third of the sternum Compress the sternum quickly and firmly to a depth of one-third of the anterior-posterior diameter of the chest Allow chest wall to return to its relaxed position between compressions Use 3:1 compression to ventilation ratio Achieve a rate of 100-120 events per minute Continue circulatory support until spontaneous heart rate is faster than 60 bpm 	<ul style="list-style-type: none"> Newborn lacks sufficient breathing and circulation despite effective inflation Deep compressions establish blood flow and cardiopulmonary circulation Heart refills with blood during relaxation phase Recommended ratio provides regular breaths with an physiological rate of 30/min Compromise of gas exchange is most cause of postnatal cardiovascular collapse
Re-assess	<ul style="list-style-type: none"> Assess every 30 s the newborn Stop ventilation if baby start to cry and evaluation shows maintained pulse > 100 bpm, regular breathing and increasing tone with legs and arms movements 	<ul style="list-style-type: none"> Heart rate and breathing change rapidly in newborns First sign of any improvement will be an increase in heart rate
Post-resuscitation care	<ul style="list-style-type: none"> Wrap the mannequin in a second warm towel and avoid cooling Place pulse oximeter on the right hand Start monitoring pre-ductal oxygenation and heart rate 	<ul style="list-style-type: none"> After NLS the newborn is at risk of later deteriorating and needs closely assessments Oxygen saturation from other extremities than from right hand is expected lower because of right-to-left shunting through the arterial duct after birth

Note: Explanations were intended only from participants in the trial group.

mannequin was placed on the thermal mattress of the infant radiant warmer unit and positioned on the back. The baby was floppy, gasped 5 times/min; the heart rate was <30 bpm, and lips and mouth were blue. The baby was wrapped with cold and wet linen. After initial assessment of breathing, heart rate and muscle tone, the newborn was expected to be stimulated and dried with warm towels. The mannequin failed to establish effective breaths and pulse raised up to 60 bpm. Opening the airway by placing the head in a neutral position and suctioning of fluid from the oropharynx was required before giving five initial breaths with an inflation pressure of 30 cm H₂O for 2-3 seconds (=initial ventilation). If chest movements were missing and heart rate failed to increase, opening the airway and initial breaths were expected to be repeated. Thereafter, the heart rate promptly increased about 80 bpm. Because of a persistent inadequate spontaneous breathing and a heart rate less than 100 bpm, the baby was expected to be ventilated at a rate of 30 breaths/min with a 1-second inflation time. With continued and skilful ventilation for 30 seconds, the mannequin started to cry, moved arms and legs. Simultaneously, the baby maintained a heart rate faster than 100 bpm, established sufficient spontaneous breathing and started to become pink. Finally, because of potential risk of later deteriorating, the newborn was expected to place in a second warm, dry towel before he was closely assessed and monitored using a pulse oximetry placed on the right hand (=post-resuscitation care).

A simulator-experienced and blinded medical student (HA) supervised the performance of each participant and changed the settings of the mannequin in response to NLS efforts.

For the simulation, a SimNewB[®] (Laerdal Medical) mannequin was used, which is a newborn tether less simulator co-created with the American Academy of Pediatrics, designed to help improve neonatal resuscitation and to meet the specific learning objectives of neonatal resuscitation protocols. Focusing on the first 10 minutes of life, SimNewB provides realistic training for critical interventions such as lung recruitment manoeuvres and advanced airway management.

The performance was recorded on video and audio using a digital camera with 14.2-megapixel resolution (Sony α NEX-5, Sony corporation), and recordings were digitally processed and anonymised. Videos were independently rated by two blinded neonatologists from the local neonatal intensive care unit. Both were experienced in teaching newborn resuscitation skills and assessing performance by means of checklists. The raters were provided with checklists of the megacode comprising 15 items with five critical skills (Figure 2). Each single item was evaluated on a 3-point performance scale (0 = not done, 1 = partially done and 2 = done correctly). In addition, the assessors measured in seconds two time points using the processed recordings: (a) time until start with successful initial ventilation and (b) time until start with post-resuscitation care once the newborn is stabilised.

2.4 | Randomisation and training

In order to maximise the standardisation of teaching, first two steps of Peyton's instruction method were implemented as a common

classroom-based seminar for all students of the group. After randomisation, the Peyton's steps 3 and 4 were conducted in small groups.

Peyton's step 1: According to Peyton's step 1, the instructor demonstrated a live NLS using the mannequin. Immediately after this, a video clip of NLS practice in the delivery room according to the European Resuscitation Guidelines was presented.

Peyton's step 2: Ensuring the second step of Peyton's approach, the trainer deconstructed each step of the newborn resuscitation on the mannequin with detailed descriptions and explanations of the procedures through a power point presentation. The trainees were encouraged to ask questions as needed at all time. After this initial predominantly theoretical lecture in the classroom and before proceeding to the critical step 3 of Peyton's approach, all students of the group were randomly assigned to control or trial group.

Randomisation: In order to perform Peyton's step 3 with a suitable trainer-to-trainee ratio, all students of the group were randomly divided into equally sized small groups of 3-4 participants. Therefore, each student picked a ticket from a box with letters representing the small groups. To receive training either by the traditional (control) or by the modified (trial) Peyton's step 3 approach, each small group was designated by blocked randomisation using random permuted blocks.

Peyton's step 3: In the control group, one trainee performed and demonstrated the NLS procedure while being talked through each single step by a peer trainee. In case that the students gave incorrect or incomplete commands, the observing trainer intervened and revisited the instructions with the training students. At the end of the NLS performance, the student who performed the tasks changed place with the next student in the group. Step 3 was repeated for each single trainee within one small group. The trial group underwent the modified approach that included functional explanations of the steps during step 3 of Peyton's method. In contrast to controls, the participants of the trial group were intended to explain in addition why they have to perform certain steps and state the importance of the correct performance/action behind it while they talked through the step. The description of single steps and their corresponding explanations are listed in Table 1. For each small group, the total duration of step 3 was recorded.

Peyton's step 4: The final step 4 in Peyton's approach was an independent, lone-rescuer performance of a newborn resuscitation. Feedback on performance was given as needed by the instructor.

2.5 | Megacode assessments

After the NLS training which is curricular and mandatory for all students, those trainees with missing informed consent or previous experience in NLS (eg previous professional paramedics) were excluded from the megacode assessments and from the final study analysis. All eligible students performed 4 days after the training the initial megacode assessment. Six months after the training, the study participants were contacted via e-mail to participate the same unassisted,

lone-rescuer NLS resuscitation scenario (follow-up megacode assessment). Students who performed an elective or internship, where NLS as well as basic life support (BLS) or paediatric basic life support (PBLs) as well as advanced cardiac life support (ACLS) might have been part of the training, were excluded from the follow-up megacode assessment to avoid any kind of bias caused by additional resuscitation training. In order to maximise the follow-up rate, each student received a book voucher after completion of both assessments.

2.6 | Statistical analysis

The data were processed and analysed using SPSS Software (IBM® Version 20). In order to account for inter-rater reliability, we calculated Pearson's correlation coefficient (*r*) for ratings between rater 1 and rater 2. Verifying testing of the data for normal distribution was performed by visual inspection of Q-Q plots. In case of strong and obvious deviation from normal assumption, we used nonparametric tests. For group sample sizes smaller or equal than 12, we used parametric tests in any case. Testing of the significant differences in the groups was calculated by Fisher's exact test. The 2-sided level of significance was set a priori at $P < .05$.

3 | RESULTS

A total of 123 students participated during their curricular, mandatory 1-week paediatric internship the NLS training. After training, we had

TABLE 2 Main characteristics of study participants by experimental group

	Control n = 42	Trial n = 52	P
Gender, n (%)			
Male	15 (35.7%)	24 (46.2%)	.400 ^a
Female	27 (64.3%)	28 (53.8%)	
Age, years	25.4 ± 2.9	26.1 ± 3.3	.250 ^b
Pre-training multiple-choice test, points	14.0 ± 3.3	14.8 ± 3.2	.187 ^c
Pre-training self-assessment ^d	3.2 ± 1.0	3.5 ± 1.2	.214 ^c
Size of small group, n (%) trio	7 (53.8%)	10 (62.5%)	.716 ^a
Quartet	6 (46.2%)	6 (37.5%)	
Duration of step-3, minutes trio	26.1 ± 7.2	24.0 ± 7.3	.588 ^c
Quartet	27.5 ± 6.1	28.3 ± 6.1	.817 ^c

Note: Values are frequencies with proportion or mean with standard deviation.

^aFisher's exact test, significant if $P < .05$.

^bMann-Whitney *U* test.

^c*t* test

^dknowledge in NLS on a six-point grading scale (1 = very good to 6 = insufficient).

to exclude 29 students from the study because of missing informed consent and/or experience in NLS, PBLs, BLS or ACLS (eg previous nurses, midwives and paramedics). The remaining 94 participants performed the initial megacode assessment 4 days after their training, and data were included for the final analysis. The demographic data of the control ($n = 42$) and trial ($n = 52$) subjects are presented in Table 2. No significant differences were found for mean age. The self-assessment score of knowledge in NLS (3.2 ± 1.0 vs 3.5 ± 1.2 , $P < .214$) and written multiple-choice test score (14.0 ± 3.3 vs 14.8 ± 3.2 points, $P < .187$) showed no significant differences. Students in both groups had comparable little theory and practical exposure in neonatal resuscitation until they entered the NLS simulation course. The distribution of trio and quartet small groups and total teaching time during Peyton's step 3 was similar in control and trial group.

Megacode results of initial and follow-up assessment are presented in Table 3. Inter-rater reliability was very high with $r > .9$. Thus, we decided to present results only for rater 1. Ratings of rater 2 are given for main outcomes, in addition. Total scores did not show significant differences between controls and trials neither in the initial (27.3 ± 2.6 vs 27.6 ± 2.3 , $P < .527$) nor in the follow-up megacode (25.6 ± 4.3 vs 25.1 ± 4.3 , $P < .748$). In the initial assessment, the time until start with initial inflation (54 ± 14 vs 63 ± 20 seconds, $P < .027$) and time until start with post-resuscitation care (144 ± 33 vs 160 ± 34 seconds, $P < .025$) were significantly higher in the trial group.

Dropout was 55 participants after initial megacode assessment, and 39 students participated in the follow-up megacode assessment, 6 months after their initial training. The dropout group and the follow-up group did not significantly differ in main characteristics except age (25.1 ± 2.9 vs 26.3 ± 3.3 years, $P < .033$). However, there was no statistically significant difference in initial megacode assessment results (Table 4).

In order to evaluate which of the groups benefitted most from the training, the mean change between initial and follow-up outcomes was compared. We found a significant loss of performance tested after 6 months irrespective of modification in step 3 ($P < .009$). Only time until start with post-resuscitation care shows a significant group difference in mean change between baseline and follow-up with increasing time in the control and decreasing time span in intervention group, respectively. Both groups showed similar scorings in the baseline, follow-up test and in mean change.

4 | DISCUSSION

Skill laboratory training is nowadays part of training programs in almost every medical faculty.²¹ Many teaching approaches are used in skill laboratories to introduce novel clinical techniques to learners. An instructional approach that is common in medical education is 'Peyton's four-step approach'.^{14,22} In this study, we evaluated whether additional functional explanation with talking through every single task during Peyton's step 3 is superior compared with solely structural explanation with an emphasis on initial and follow-up/long-term knowledge and skill retention in NLS.

TABLE 3 Comparison of the initial and follow-up assessments of rater 1 (with additional *P*-values of rater 2)

	Initial (n = 94)			Follow-up (n = 39)			Initial vs follow-up	Mean change ^a
	Control n = 42	Trial n = 52	<i>p</i> ^b	Control n = 17	Trial n = 22	<i>p</i> ^b	<i>p</i> ^c	<i>p</i> ^b
Total score (max. 30 points)	27.3 ± 2.6	27.6 ± 2.3	.527	25.6 ± 4.3	25.1 ± 4.3	.748	.009*	.469
Time until start with initial inflation, seconds	54 ± 14	63 ± 20	.027*	52 ± 20	57 ± 16	.413	.602	.421
Time until start with post-resuscitation care, seconds	144 ± 33	160 ± 34	.025*	152 ± 43	140 ± 22	.313	.672	.028*
<i>P</i> -values of rater 2			<i>p</i> ^b			<i>p</i> ^b	<i>p</i> ^c	<i>p</i> ^b
Total score (max. 30 points)			.358			.960	.011*	.588
Time until start with initial inflation, seconds			.047*			.484	.603	.594
Time until start with post-resuscitation care, seconds			.022*			.371	.602	.019*

Note: Values are given in mean with standard deviation.

^aDifference between initial and follow-up outcome.

^bControl vs trial assessment compared by unpaired *t* test.

^cCompared by paired *t* test.

*Significant if *P* < .05.

Bold values denote statistical significance at the *P* < .05 level.

The modification in step 3 with additional explanation and talking through the single steps did not prolonged the length of the training itself in the trial group. This is crucial, since a different learning period during step 3 might have facilitated the acquisition and retention of skills. We observed that traditional and modified taught students experienced comparable and excellent skills short after the NLS training. This finding was expected, since training in general has been proven to positively influence the short-term gain of skills and knowledge when compared with no intervention. Surprisingly, the initial megacode assessment revealed that time until start with initial inflation and beginning of post-resuscitation care was significantly longer in the trial group than in the control group. This might be an effect of the intervention in step 3, that students in the trial group were requested to explain the meaning and importance of their actions during the training. We noticed, that participants in particular of the modified group commented more in detail on their actions during the megacode assessments. This fact might have led to the slight, but significant delay regarding the length of the initial megacode performance within trial group.

The follow-up megacode assessment showed an overall loss of knowledge for both groups irrespective of the explanation method during step 3. Nevertheless, we found an association between the training method and the time needed until the onset of post-resuscitation care. The time until start with post-resuscitation care showed a significant group difference in mean change between initial and follow-up with increasing time in the control and decreasing period in the trial group. This difference in rapidity might be due to the differing training methods. We assume that an active verbalisation in step 3 caused an improved rooting of knowledge and anchoring of skills within the trial group. They seemed to be able to recall their knowledge more rapidly after 6 months when

compared with the control group. This is consistent with studies showing that verbalisation might lead to a better long-term retention resulting in a faster accessibility of skills. There are studies indicating that 'think aloud', 'verbalisation' or 'self-explanation' can be used to teach and assess clinical reasoning and promote long-term retention.²³ Overall, we cannot rule out that verbalisation in the trial group might be a potential confounder of the reported association between intervention and shorter time until start with post-resuscitation care in the current study. However, we consider this confounder being minored by the fact that participants commented on tasks in both assessments.

The decline in overall test score over 6 months in both experimental groups in our study is in good accordance with previous studies. The accessibility of medical expertise, like resuscitation skills, decreases over time if not trained and applied regularly. Many studies with lay people as well as medical professionals could demonstrate that knowledge and skills accessibility decline even early after training.¹⁹ Nowadays, modern technique tools like serious gaming or virtual reality have to be proven to be an effective method to ensure skill and knowledge retention.²⁴

Research in the field of medical education recognises the four-step method as a valuable and easy-to-use tool and well accepted by students. Krautter et al¹⁷ were able to prove the effectiveness of Peyton's four-step method in teaching gastric tube insertion using a mannequin. In a randomised controlled trial, medical students were randomly assigned to a control group receiving standard instruction and an intervention group receiving instruction according to Peyton's four-step approach. The first gastric tube insertion in both groups was videotaped and evaluated by two independent physicians. The two groups did not differ in terms of correct stepwise

TABLE 4 Comparison of dropouts and follow-up

	Follow-up n = 39	Dropout n = 55	P
Study participants, n (%) control	17 (40.4%)	25 (59.6%)	.999 ^a
Trial	22 (42.3%)	30 (57.7%)	
Gender, n (%)			
Male	12 (30.8%)	27 (69.2%)	.092 ^a
Female	27 (49.1%)	28 (51.0%)	
Age, years	25.1 ± 2.9	26.3 ± 3.3	.033 ^b
Pre-training multiple-choice test, points	14.9 ± 3.1	14.1 ± 3.4	.260 ^c
Pre-training self-assessment ^d	3.3 ± 0.9	3.4 ± 1.3	.508 ^c
Results from the initial assessment			
Total score (max. 30 points)	27.3 ± 2.7	27.6 ± 2.3	.668 ^c
Time until start with initial inflation, seconds	57.2 ± 15.9	60.7 ± 20.5	.369 ^c
Time until start with post-resuscitation care, seconds	109.9 ± 26.0	117.8 ± 31.4	.351 ^c

Note: Values are frequencies with proportion or mean with standard deviation.

^aFisher's exact test, significant if $P < .05$.

^bMann-Whitney U test.

^c t test.

^dKnowledge in NLS on a six-point grading scale (1 = very good to 6 = insufficient).

Bold values denote statistical significance at the $P < .05$ level.

performance of the procedure which was assessed by a checklist. However, ratings based on a global rating scale assessing professionalism and accompanying patient-doctor communication proved to be significantly better in the intervention group. Krautter et al²⁵ assumed that these results attributed mainly to the 3rd step of Peyton's approach. In the education of NLS and PBL skills, Peyton's method is used as the standard teaching method and recommended by the European Resuscitation Guidelines.⁷ Many studies evaluated and compared Peyton's four-step method with a traditional 2-step approach.²⁶ Nikendei et al used a modified approach of Peyton's four-step method to instruct small groups. As P4S was initially designed for a 1:1 teacher-to-student ratio, the aim of Nikendei et al²⁷ was to develop and evaluate a new Peyton's approach in terms of small-group teaching. Yet data on any kind of modification in Peyton's four-step method remain sparse.

Our study does have some limitations. We did not increase difficulty level, nor did we evaluate different types of scenarios. Skills that involve mastery in the cognitive, technical and process domains may well benefit from P4S method of teaching; however, it might be possible that this approach is not useful in skills that are too simple or too complex. Unfortunately, the dropout before long-term assessment was relatively large, despite our best efforts and offering of

book gifts for participating. However, the sampling of dropout and follow-up groups was comparable except mean age.

The question remains whether P4S is superior to any other teaching method when it comes to CPR training and teaching in general and NLS in particular. Almost two decades ago, the four-stage approach was introduced as a new method of teaching clinical skills consisting of four different sequential steps (demonstration, deconstruction, comprehension and performance). Although it has been integrated into teaching programs at various educational institutions and training centres, such as the European Resuscitation Council, it is often considered too slow and repetitive, while its effectiveness and efficiency compared with traditional teaching has not been proven.

Indeed, the evidence regarding its effectiveness remains scarce. Greif et al¹¹ evaluated whether the four-stage approach results in shorter performance time needed for a successful percutaneous needle-puncture cricothyroidotomy and reported that the effectiveness of P4S was comparable to traditional teaching methods and that its use or omitting step 2 and 3 of Peyton's approach does not lead to superior learning. In this study, however, the instructors were not required to follow a standardised script and were not blinded to tuition group during the outcome assessment, which could have introduced bias. Also, the study was limited to measuring skill acquisition and did not include a skill retention follow-up arm. Jenko et al²⁸ compared the two- and four-stage basic life support teaching technique and tested if students' self-evaluated knowledge was in accordance with their actual knowledge. They reported that the four-stage technique did not improve significantly the quality of chest compressions, while the students' self-evaluation of their performance after the course was too high. In another study, Bitsika et al²⁹ reported that skill retention was not associated with either of the two methods.

The priority that should be given to each of the individual components of motor skills teaching is difficult to quantify and is the subject of future research. The four-stage approach has been used for years in different field and subspecialties of resuscitation training. The evidence of better skill acquisition and retention compared with traditional methods yet remains scarce. Romero et al though could demonstrate that there is an advantage of the PS4 method compared with the Halsted's 'See One, Do One and Teach One' when it comes to learning complex skills like laparoscopic suturing and knot tying.³⁰

Medical educators need high-quality data to address the knowledge gaps for this topic, and this study might set a precedent for future research. We recommend using the modified four-stage Peyton's approach for skill teaching because we are convinced that giving addition detailed background information and how, why and when certain procedural skills have to be performed have a positive effect on memorising a skill and long-term knowledge retention respectively.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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